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ABSTRACT

This handbook features ideas for implementing Project WET activities in Virginia. Project WET activities are designed for a variety of educational programs and can be used to complement existing curricula while addressing curricular objectives and educational standards nationwide. Activities include: (1) "Life Systems"; (2) "Atmospheric Water/Precipitation"; (3) "General Surface Water/Distribution"; (4) "Movement of Water Over Earth's Surface"; (5) "Groundwater"; (6) "Natural Disasters"; (7) "Waterborne Disease"; (8) "Public Process"; (9) "Wastewater Management"; (10) "Water Rights"; (11) "Water History"; (12) "Water Science"; (13) "Water Users"; (14) "Watersheds"; (15) "Wetlands"; (16) "Virginia's Water Fact Sheet"; (17) "Making Water Usable"; (18) "Treating Wastewater"; (19) "Septic Tanks"; (20) "Desalination"; and (21) "Contaminants in the Water: How Much is Too Much." (CCM)

PROJECT WET®

Water Education for Teachers

A Handbook for Implementing Project WET Activities in Virgina

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
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DEQ
VIRGINIA DEPARTMENT OF ENVIRONMENTAL QUALITY

Project Wet

Facilitator Handbook

for

Implementation of Activities

in Virginia

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Introduction

Project WET activities are designed for a variety of educational programs and complement existing curricula while addressing curricular objectives and educational standards nationwide. The **Curriculum Guide** is organized in five different ways to allow educators to locate activities to meet their teaching needs. One method of organization is the Water Units chart on page xiii in the Guide. Using the Water Units framework, this handbook incorporates Virginia-specific resources and information that could be used with the activities to give it a local focus. The resources listed are not all inclusive, but are the ones made available to facilitators in the WET bucket or the groundwater traveling trunks. Many of the resources are useful with more than one activity and the ones listed in the chart under each unit are only suggestions.

In addition to these materials, facilitators might find it helpful to begin a clipping file of water articles in the newspaper, sporting magazines, and agency newsletters. Such items will make many of the activities more relevant to students and will provide facilitators with handouts to use in conducting workshops in their area. You also can contact the Department of Environmental Quality for newspaper clippings.

LIFE SYSTEMS

Project WET Curriculum and Activity Guide lists five activities that could form a unit of study on life systems. All of the activities relate to the theme that water is essential for all life to exist. There are 12 activities listed under this theme, including all five under the life systems unit. The activities are for kindergarten through middle school and require from 30 to 90 minutes to complete. Resource materials available to enrich this unit and give it a Virginia focus are included in the traveling trunks and the WET buckets. Others are available from Virginia agencies, organizations and the Cooperative Extension Service.

The available publications about life systems, water cycle, water-related adaptations, osmosis, diffusion, and water in the human body are:

1. *Be Water Wise*
2. *Facts about Virginia's Waters*
3. *Desalination* (enclosed handout)
4. *Threats to Virginia's Groundwater*
5. *National Geographic Edition* "Water"
6. *Facts about Virginia's Waters*
7. *Chesapeake Bay: Introduction to an Ecosystem*
8. *The Water Cycle: Nature's Recycling System Poster*
9. Audio tapes of water songs

Activity Name	Conceptual Framework	Activity Duration	Page No.	Virginia Resource
"Aqua Bodies" Estimate the amount of water in a person, a cactus, or a whale	Water is essential for all life.	90 minutes	63	1
"Aqua Notes" Sing to discover how the human body uses water.	Water is essential for all life.	30 minutes	66	1, 9
"Water Address" Analyze clues to match organisms with water-related adaptations.	Water is essential for all life.	50 minutes	122	2, 6, 7
"Let's Even Things Out" Demonstrate osmosis and diffusion.	Water is essential for all life.	5 50 minutes	72	3, 4, 5
"Thirsty Plants" Demonstrate transpiration and conduct a field study.	Water is essential for all life.	70 minutes	116	2, 4, 5, 8

"Aqua Bodies" and "Aqua Notes"

Understanding how much of the body is made up of water is the focus of the "Aqua Bodies" activity for elementary students. Students trace an outline of their body on butcher paper and color 70 percent to show what portion is water. Simple songs about water in the body in the activity "Aqua Notes" help students understand how water transports nutrients throughout the body, keeps temperature stable, provides lubrication and digestion. The student activity book *Be Water Wise* contains similar information on water in the body and gives percentages of water contained in various body parts, i.e. the brain is 75 percent water.

"Water Address"

Recognizing the water-related adaptations of plants and animals is the objective of the activity "Water Address." During the warm-up, students are to discuss the different ecosystems and water availability in their areas. Using the brochure *Facts about Virginia's Waters,"* students should identify the river basin where they live and what type of plants and animals live there. Compare the plants and animals of the river basin with another river basin in the state. Because of the diversity of the nine Virginia river basins, this activity can be adapted to have water address cards for plants and animals in each river basin. The booklet *Chesapeake Bay: Introduction to an Ecosystem"* contains a chapter on the more than 2,700 species of plants and animals inhabiting the Chesapeake Bay and its shoreline.

"Let's Even Things Out"

Describing and demonstrating the process of osmosis and diffusion will help elementary and middle school students learn the role water plays in dispersing solutes, how nutrients are diffused, and how cells maintain water balance. "Let's Even Things Out" amplifies the theme of how living things use water. One of the assessment exercises is to research and cite examples of osmosis and diffusion in their bodies and in the environment. The enclosed handout on *Desalination* should be of interest. Older students might want to research the use of desalination plants in Virginia to provide drinking water to populated Virginia coastal communities. "Saltwater Intrusion" is discussed in *Threats to Virginia's Groundwater* and the areas of potentially salty aquifers is illustrated.

"Thirsty Plants"

The role plants play in the water cycle is the focus of this activity for middle school students. After demonstrating how plants draw up water and evaporate it to the atmosphere, students might want to discuss the water needs of various plants in Virginia. The water cycle diagrams and cartoon are included in *Be Water Wise* and *Threats to Virginia's Waters*. The poster *The Water Cycle: Nature's Recycling System* shows transpiration and the back contains such interesting water facts as "Every year, about 15,000 cubic miles of water evaporate from the Earth's surface."

Although there are fewer communities in our state that practice xeriscaping than do more arid western states, the concept of using native plants and trees for landscaping is an important one. In the U.S. each day, 137 billion gallons of water is used for irrigation--mostly agricultural crops. In some areas of Virginia, particularly the Eastern Shore, irrigation of crops is practiced to provide necessary water to such thirsty plants as cantaloupes, tomatoes, other garden vegetables. About 20 million gallons of water are used each day for irrigation in Virginia. Students might want to research the irrigation patterns and practices in Virginia with other states. They can get additional information from their local Extension agent.

ATMOSPHERIC WATER/PRECIPITATION

There are six activities listed under this unit for grades K-12. Time estimates for conducting the activities range from 30minutes for part of an activity to up to one week for the "Wet Vacation" activity. All put one activity focuese on the theme that water connects all earth systems. During this unit students will During this unit, students will be applying and practicing the skills defining a problem, analyzing, synthesizing, and evaluating information, and planning, implementing, and evaluating action.

The following Virginia resources, which are available to Project WET facilitators in the traveling trunks and the WET Facilitator notebook and folders,will be helpful in conducting this unit:

1. *Threats to Virginia's Groundwater*
2. *Be Water Wise*
3. *Audio Tape of Water Songs*
4. *Water Cycle Poster*

Activity Name	Conceptual Framework	Activity Duration	Page No.	Virginia Resource
"Water Match" Discover the three states of water	Water has unique physical and chemcial characteristics	80 minutes	50	1, 2, 4
"A House of Seasons" Reveal of the role of water in each season	Water connects all earth systems.	50 minutes	155	4
"The Thunderstorm" Simulate the sounds of a thunderstorm and create precipitation maps.	Water connects all earth systems.	80 minutes	196	1, 2
"Poetic Precipitation" Express feelings toward precipitation through poetry.	Water connects all earth systems.	100 minutes	182	3
"Wet Vacation" Plot data to determine weather patterns and design appealing travel brochures.	Water connects all earth systems.	50 minutes	206	-------
"Piece It Together" Explore global climates and their influences on lifestyles.	Water connects all earth systems.	90 minutes	174	------

General Surface Water/Distribution

There are six activities that form the unit on surface water/distribution. All but one of the activities relates to the theme that water connects all earth systems. The activity "Dust Bowls and Failed Levees" relates to the theme water resources are managed. The activities are for upper elementary through high school, but there is a K-2 option for one of the activities. The time required to do the activities range from 30 to 100 minutes. The "Dust Bowls and Failed Levees" can take up to two weeks to complete.

The available publications about the water cycle, water resources management, and protection of acceptable water quality and quantity are found in the following publications:

1. *Threats to Virginia's Groundwater*
2. *Sandcastle Moats and Petunia Bed Holes*
3. *River Basin Fact Sheets*
4. *Be Water Wise*
5. *Facts about Virginia's Waters*
6. *Groundwater Map of Virginia*
7. *National Geographic Edition "Water"*
8. *The Water Cycle Poster*
9. *Bay BC's*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"A Drop in the Bucket" Calculate the availability of fresh water on Earth	Water connects all earth systems.	30 minutes	238	4, 8
"Branching Out" Construct a watershed model	Water connects all earth systems.	100 minutes	129	3, 5, 9
"Old Water" Create a mural that relates events to the age of Earth, water, and life	Water connects all earth systems.	100 minutes	171	1, 2, 6
"Wet Vacation" Plot data to determine weather patterns and design appealing travel brochures	Water connects all earth systems.	50 minutes	206	---------
"Piece It Together" Explore global climates and their influences on lifestyles	Water connects all earth systems	90 minutes	174	---------
"Dust Bowls & Failed Levees" Witness the effects of drought and flood on human populations	Water resources are managed	Variable	303	7

Movement of Water Over Earth's Surface

There are three activities in this unit for students in grades 3 - 12. Two themes are utilized in this unit. The first is that water is a natural resource and that the available freshwater supply on Earth is limited and must sustain multiple users. The second theme is water connects all Earth systems and is an integral part of the Earth's structure. The water cycle is central to life on Earth. The activities take from 50 to 100 minutes.

Some of the available publications to use with this unit are

1. *Be Water Wise*
2. *National Geographic Edition "Water"*
3. *The Water Cycle Poster*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"The Incredible Journey" Simulate the movement of water through Earth's systems	Water connects all systems.	100 minutes	161	1, 3
"Water Models" Construct models of the water cycle and adapt them for different biomes	Water connects all systems.	100 minutes	201	1, 3
"Great Water Journey" Use clues to track great water journeys of plants, people, and other animals on a map	Water is a natural resource.	50 minutes	246	1, 2

GROUNDWATER

Project WET Curriculum and Activity Guide lists three activities that could form a groundwater unit. Two additional activities to supplement the unit are listed in the Topic Index that begins on page 480. All of the activities are for middle and high school students and require from 30 to 110 minutes to complete. A number of Virginia resources and materials are included in your WET bucket and can be used to enrich this unit. Additional materials are included in the traveling trunks housed at state parks and other sites listed in your WET handbook.

The available Virginia publications about groundwater are:

1. *Groundwater model*
2. *Sandcastle Moats and Petunia Bed Holes*
3. *Geologic map of Virginia*
4. *Threats to Virginia's Groundwater*
5. *Springs of Virginia*
6. *All the Water in the World* (enclosed handout)

Activity Name	Conceptual Framework	Activity Duration	Page	Va Resource
"Get the Groundwater Picture" Investigate the porosity and permeability of soil and look at the groundwater system.	Water connects all systems	110 minutes	136	1,2, 3, 4
"A Drop in the Bucket" Calculate the availability of fresh water on Earth	Water is a natural resource	30 minutes	238	6
"Geyser Guts" Demonstrate the workings of a geyser.	Water connects all systems	90 minutes	144	5
"The Pucker Effect" Simulate groundwater testing to discover the source of contamination.	Water resources are managed	100 minutes	338	2, 3
"A Grave Mistake" Analyze data to solve a groundwater mystery.	Water resources are managed	50 minutes	311	2, 3, 4

"Get the Groundwater Picture"

In this activity students look at the porosity and permeability of soil and create a geological cross section. There are several resources that will make the activity Virginia-specific.

- The *groundwater flow model* is a Plexiglas sand model, that demonstrates basic groundwater principles and management concerns. The models are housed in traveling trunks that also contain a video on how to use the model and a number of educational resources about groundwater.

- Two demonstrations in *Sandcastle Moats and Petunia Bed Holes* illustrate how water molecules move through gravel, sand, and clay. The demonstration on page 9 shows porosity and the one on page 10 is about permeability. Both demonstrations use gravel, sand, clay, and a soil mixture. The demonstrations can be used as an extension of the activity or as an experiment for older students.

- Because the geology of Virginia is very diverse, students will need to know how the various regions of the state differ. A *geologic map of Virginia* will help students compile the well log/groundwater cross section in this activity.

- The Commonwealth has five distinct physiographic provinces of similar geology, topography, soil types, climate, and aquatic resources. These are described very briefly in this handbook and in more detail in *Threats to Virginia's Waters*.

"The Pucker Effect" and "A Grave Mistake"

These two activities focus on groundwater contamination and discovering the source of contamination. Two demonstrations from *Sandcastle Moats and Petunia Bed Holes* can be used to amplify these two activities. The first on leaching is on page 14 and demonstrates how groundwater dissolves soluble materials and carries them through the earth. The second demonstration on landfills on page 17 shows how items buried in the ground can affect groundwater in much they same way that 19th century graves can. In addition, information on superfund sites and acid mine drainage problems discussed in *Threats to Virginia's Waters* can be used to provide a Virginia perspective to groundwater contamination.

"A Drop in the Bucket" and "Geyser Guts"

These two activities are suggested as supplemental ones for use in a groundwater unit. Although Virginia does not contain any geysers, the Commonwealth does contain a number of hot springs. A discussion on geothermal energy and the mineral content of both geysers and hot springs in *Springs of Virginia* could be used to make the materials more relevant. The enclosed handout, "All the Water in the World" provides an additional way to demonstrate the availability of fresh water on Earth.

NATURAL DISASTERS

There are four activities in this unit on natural disasters for students in grades 3 - 12. Each activity focuses on a different theme and can take from 50 minutes to 150 minutes. "The Thunderstorm" is a good water cycle activity to show that all Earth systems are connected. Water resources are managed is the main theme of "AfterMath" and illustrates that many management decision involve the distribution of water resources. In the activity "Nature Rules," the theme is that water is a natural resource and water plays a prominent role in many of the events we call natural disasters. Countries around the world hold similar and contrasting views toward water. The activity "How Water" has students debating controversial water issues and problems.

The following resources will be helpful in conducting this unit:

1. *Threats to Virginia's Waters*
2. *Be Water Wise*
3. *Natural Geographic Edition "Water"*
4. *Chesapeake Bay: Introduction to an Ecosystem*
5. *Water Cycle Poster*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"The Thunderstorm" Simulate the sounds of a thunderstorm and create precipitation maps	Water connects all earth systems.	80 minutes	196	1, 2
"AfterMath" Assess economic effects of water-related disasters	Water resources are managed.	50 minutes	289	3
"Nature Rules" Write news stories based on natural, water-related disasters	Water is a natural resource.	150 minutes	262	3
"Hot Water" Debate water issues	Water resources exist within social constructs.	100 minutes	388	1, 4

WATERBORNE DISEASE

Three activities make up this unit on waterborne disease for students in grades 3 - 12. All three focus on the theme that water is essential for all life to exist and that life processes from the level of the cell to that of the ecosystem depend on water. Both the quantity and the quality of water contribute to the sustainability of life on Earth. The discussion on Giardia in *Springs of Virginia* will be useful in these activities.

Other helpful resources are listed below:

1. *Springs of Virginia*
2. *Threats to Virginia's Groundwater*
3. *National Geographic Edition "Water"*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"No Bellyaches" Show how pathogens are transmitted by water by playing a game of tag.	Water is essential for all life.	50 minutes	85	1
"Poison Pump" Solve a mystery about a waterborne disease.	Water is essential for all life.	50 minutes	93	2, 3
"Super Sleuths" Search for others who share similar symptoms of waterborne disease	Water is essential for all life.	50 minutes	107	1, 2

PUBLIC PROCESS

The unit on public process is designed with activities for middle and high school students, except for the water index in "Choices and Preferences," which can be used as a K-2 option. The time required to conduct the ranges from 50 minutes to 150 minutes. Newspaper accounts of current Virginia water issues such as the Lake Gaston Pipeline, the Chesapeake Bay, and toxic wastes will make this unit more meaningful to students. Newspaper archives and public libraries often contain clipping files that can be searched.

The following resources may be helpful in conducting this unit:

1. *Be Water Wise*
2. *Facts about Virginia's Waters*
3. *Threats to Virginia's Waters*
4. *National Geographic Edition "Water"*
5. *Chesapeake Bay: Introduction to an Ecosystem*
6. Newspaper articles
7. *Aquatic Resources and Nonpoint Source Pollution*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"Choices and Preferences" Develop a water index to rank water uses	Water resources exist within social constructs	50 minutes	367	1, 4
"Dilemma Derby" Examine differing values in resolving water resource management dilemmas	Water resources exist within social constructs	50 minutes	377	2, 7
"Water Bill of Rights" Create a document to guarantee the right to clean and sustainable water resources	Water resources exist within social constructs	100 minutes	403	3
"Whose Problem Is It?" Analyze the scope and duration of water issues to determine personal and global significance.	Water resources exist within social constructs	50 minutes	429	4, 6, 7
"Hot Water" Debate water issues	Water resources exist within social constructs	100 minutes	388	3, 5, 6
"Water Court" Participate in a mock court to settle water quality and quantity disputes	Water resources exist within social constructs	150 minutes	413	3, 4, 6, 7

Wastewater Management

Project WET Curriculum and Activity Guide lists six activities that form a wastewater management unit. The activities are appropriate for lower elementary through high school students. They require between 30 minutes and 100 minutes. There are a number of resources and materials available to enrich this unit included in the traveling trunks and WET buckets. Others are available from Virginia agencies and organizations.

The available publications about nonpoint source pollution, water and wastewater treatment, macroinvertebrates, and water management are:

1. *National Geographic Edition "Water"*
2. *Aquatic Resources and Nonpoint Source Pollution*
3. *Be Water Wise Activity Book & Brochure*
4. *Facts about Virginia's Waters*
5. *Treating Wastewater*
6. *Septic Tanks*
7. *Making Water Usable*
8. *Desalination*
9. *Contaminants in Water: How Much is Too Much*
10. *Bay BC's (K-4 lesson plans)*
11. *Chesapeake Bay: Introduction to an Ecosystem*

Activity Name	Conceptual Framework	Activity Duration	Page	Resource
"Rainy-Day Hike"(K-2 Option) Explore schoolyard topography and its effect on the watershed	Water connects all Earth systems.	100 minutes	186	10
"A-maze-ing Water" Investigate nonpoint source pollution	Water is a natural resource	30 minutes	219	1, 2, 4, 10, 11
"Macroinvertebrate Mayhem" Macroinvertebrate populations indicate water quality	Water resources are managed	50 minutes	322	1, 2
"Reaching Your Limits" Meeting drinking water standards	Water resources are managed	50 minutes	344	1, 3, 7
"Sparkling Water" Removing contaminants from wastewater.	Water resources are managed	100 minutes	348	1, 4, 5, 6
"The Price is Right" The costs of water and wastewater treatment	Water resources are managed	50 minutes	333	1, 3, 5, 7, 8
"Perspectives" Identify values to solve water management issues	Water resources exist within social constructs	50 minutes	397	1, 4, 9, 11

"A-maze-ing Water"

Investigating the sources of nonpoint source pollution in an urban watershed is the focus of this activity. Students, representing water flowing through drainage pipes to the river or water treatment plant run a maze picking up pollutants and becoming contaminated stormwater. Using the supplemental resources suggested in the unit chart, a variety of pollutants can be identified and discussed. The brochure *"Facts about Virginia's Waters"* (resource #4) shows the river basins in the state and the areas they drain and lists nine threats to our water resources. This activity could be modified to have the Chesapeake Bay be the destination of the urban stormwater. Another modification would be to use brightly colored sticky notes instead of bowls of flour. Have the students write the various urban pollutants they have identified in the resource materials on the sticky notes.

The action project suggested for this activity is a storm drain stenciling program. Some communities in Virginia have stenciled drains with "DUMP NO WASTE -- DRAINS TO THE BAY." For more information on these programs contact the Chesapeake Bay Foundation, Suite 815 Heritage Building, 1001 East Main Street, Richmond, VA 23219 or the Center for Marine Conservation, 306A Buckroe Avenue, Hampton, VA 23664. [1]

"Macroinvertebrate Mayhem"

Students will simulate how environmental stressors affect macroinvertebrates in a stream and will investigate how these populations are indicators of water quality. A natural extension of the simulation and tag game in the activity is to have students conduct macroinvertebrate surveys of a local stream. A number of communities and school organizations monitor streams in their area and report the results to state agencies. One monitoring program is the "Save Our Streams" program from the Izaak Walton League, 707 Conservation Lane, Gaithersburg, MD 20878-2983.[2]

"Reaching Your Limits"

Making water safe enough to drink is the focus of this activity. *"Making Water Usable"* describes the steps in treating drinking water. In this activity students play a game of limbo to demonstrate the amount of effort required to treat water to meet federal and state drinking water standards. Understanding how little a certain contaminate can pollute water and make it unfit to drink is a difficult concept for some students. The enclosed handout

[1] The zip code listed in the Project WET guide is not complete.
[2] This is the current address. The address listed in the Project WET guide is incorrect.

"Contaminants in Water: How Much is Too Much" may help. A field trip to a water treatment plant is a good way to tie this activity to the local community. Many water treatment facilities in Virginia have an open house during the first week of May, which is usually designated Drinking Water Week. Another program, "Give Water a Hand," also focuses on water treatment and is available from your local extension agent.

"Sparkling Water"

Wastewater treatment to remove contaminants is the subject of this activity. The two handouts *"Treating Wastewater"* and *"Septic Tanks"* contain diagrams that should be useful in describing the process involved. In the warm up procedure it is suggested that students be asked if they have heard of the river that burned. On page 81 of *"National Geographic Edition: Water"* there is a discussion of the Cuyahoga River in 1969 and the passage of the Clean Water Act. Closer to home, the Potomac River was so polluted with sediment and industrial waste that President Lyndon B. Johnson in 1965 ordered a cleanup to make the river "a model of beauty." Some additional Virginia wastewater problems are listed in the brochure *"Facts about Virginia's Waters."*

"The Price is Right"

In this activity high school students investigate the cost of water and wastewater treatment projects as they design these community systems. All of the listed resources will be helpful in this activity. The handout on *"Desalination"* brings a Virginia issue into the discussion. A presentation by a local engineering firm that builds such facilities might be interesting to students. In addition, information about "Best Management Practices" should be obtained from the regional office of the Virginia Department of Environmental Quality or the Department of Conservation and Recreation.

"Perspectives"

Students will identify a water resource management issue and evaluate the pros and cons of proposed solutions. A number of issues about the Chesapeake Bay will make this activity relevant to the middle and high school students. *"Facts about Virginia's Waters"* and *"Chesapeake Bay: Introduction to an Ecosystem"* have helpful information. The Chesapeake Bay Foundation, Suite 815 Heritage Building, 1001 East Main Street, Richmond, VA 23219 and the Virginia Department of Game and Inland Fisheries, Box 11104, Richmond, VA 23230-1104 have many publications, posters, and educational materials that could be used in this activity. The case study

"Where Two Worlds Collide" on page 66 of *"National Geographic Edition: Water"* discusses the damming of the Great Whale River and the conflicting issues that are involved.

NOTE: One additional activity has been suggested to be included in this unit. Because "Rainy-Day Hike" focuses on watersheds and also is included in a watershed unit, it has not been included in this unit description.

WATER RIGHTS

Five activities make up the unit on water rights for grades 3 - 12. Two themes are used: water connects all earth systems and water exist within social constructs. There are several opportunities to use Virginia-specific information and examples in these activities. For example, the activity "Water Court" could use newspaper accounts of the legal struggle arising from the water supply pipeline between Lake Gaston and Virginia Beach. The activity "Hot Water" calls for a debate and has as one of its objectives for students to recognize the effectiveness of reason-based versus emotion-based presentations. One current issue involves what to do with the runoff from the abandoned Kim-Stan Landfill near Covington. More information about these current issues can be found in the archives of Virginia newspapers (some are available over computer networks) and through the Virginia Department of Environmental Quality and their regional offices. Virginia laws are briefly discussed in *Threats to Virginia's Waters* and federal laws are discussed in the *National Geographic Edition "Water."*

The following publications will be useful in conducting this unit:

1. *Be Water Wise*
2. *Threats to Virginia's Groundwater*
3. *Chesapeake Bay: Introduction to an Ecosystem*
4. *National Geographic Edition "Water"* and the included national map
5. Newspaper articles

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"A Drop in the Bucket" Calculate the availability of fresh water on Earth	Water connects all Earth systems.	30 minutes	238	1
"Wet Vacation" Plot data to determine weather patterns and design appealing travel brochures	Water connects all Earth systems.	50 minutes	206	4 (map)
"Pass the Jug" Simulate water rights policies with a jug of water	Water resources exist within social constructs	60 minutes	392	1, 2
"Hot Water" Debate water issues	Water resources exist within social constructs	100 minutes	388	2, 3, 5
"Water Court" Participate in a mock court to settle water quality and quantity disputes	Water resources exist within social constructs	150 minutes	413	2, 4, 5

WATER HISTORY

The Water History unit is multi-subject with interdisciplinary themes and activities. There are eight activities for grades 3 - 12 and four themes that include a focus on social and cultural constructs. The activities in this unit will complement existing curricula in the subjects of fine arts, language arts, history, geography, math, all of the sciences, and health. Virginia's rich history provides many opportunities to make the unit Virginia-specific. For example, the first public utility in the Colonial America was a ferryboat operation to carry citizens across Virginia's tidal rivers from the principal settlements to the outlying plantations. Ferry crossing points became the starting points for highways and roads. Later bridges spanned the rivers between these points. This information could be used in the activity "Water Crossing." Other historical information that could be used in this unit can be found in *Virginia's Waters,* * an out-of-print publication available in most school libraries.

Other resources useful in conducting this unit:

1. *Be Water Wise*
2. *Threats to Virginia's Groundwater*
3. *Sandcastle Moats and Petunia Bed Holes*
4. *Groundwater Map of Virginia*
5. *National Geographic Edition "Water"* map
6. *Virginia's Waters*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"Water Messages in Stone" Replicate ancient rock art, creating symbols of water	Water resources exist within cultural constructs.	50 minutes	454	-----
"The Rainstick" Build an instrument that imitates the sound of rain	Water resources exist within cultural constructs.	Up to 1 week	442	-----
"Water Concentration" Play concentration and discover how water use practices evolve	Water resources exist within social constructs.	80 minutes	407	1
"Old Water" Create a mural that relates events to the age of Earth, water, and life	Water connects all earth systems.	100 minutes	171	2, 3, 4
"Water Crossings" Simulate a water crossing and relate the historical significance of waterways	Water resources exist within social constructs.	150 minutes	421	5, 6
"The Long Haul" Haul water to appreciate the amount of water used daily	Water is a natural resource.	50 minutes	260	1
"Wish Book" Compare recreational uses of water in the late 1800s and the present	Water resources exist within cultural constructs.	50 minutes	460	6
"Easy Street" Compare quantities of water used in the late 1800s and in the present	Water resources exist within social constructs.	80 minutes	382	1

* Sevebeck, Kathryn P., Jacob H. Kahn, and Nancy L. Chapman. 1986. *Virginia's Waters.* Virginia Water Center, Virginia Polytechnic Institute and State University, Blacksburg, Va.

WATER SCIENCE

All of the seven activities in this water science unit focus on the unique physical and chemical characteristics of water. Students in grades K - 8 will find there is a card game to teach about the three states of water, a water olympics to investigate two properties of water, a game of charades to demonstrate four properties of water, an experiment with salty water, and a demonstration of water's ability to dissolve solids, liquids, and gases. There is even a crime to solve.

The resources available to augment this unit are:

1. *Be Water Wise*
2. *Water Cycle Poster*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"Water Match" Match water picture cards and discover the three states of water	Water has unique physical and chemical characteristics.	80 minutes	50	1, 2
"Molecules in Motion" Simulate molecular movement in water's three states	Water has unique physical and chemical characteristics.	50 minutes	47	1, 2
"H_2Olympics" Compete in a water olympics to investigate adhesion and cohesion	Water has unique physical and chemical characteristics.	50 minutes	30	1, 2
"Hangin' Together" Mimic hydrogen bonding in surface tension, ice formation, evaporation, and solutions	Water has unique physical and chemical characteristics.	90 minutes	35	1, 2
"Adventures in Density" Experiment with density and explore examples of density in classic literature	Water has unique physical and chemical characteristics.	100 minutes	25	1, 2
"What's the Solution" Solve a crime while investigating the dissolving power of water	Water has unique physical and chemical characteristics.	50 minutes	54	1, 2
"Is There Water on Zork" Test the properties of water	Water has unique physical and chemical characteristics.	100 minutes	43	1, 2

WATER USERS

Students in K-12 can participate in a water users unit The three themes focused on in the unit are that water is a natural resource; it exists within social constructs; and, is managed. The time to conduct several of the activities can vary and take as long as one week. Upper elementary and middle school students will enjoy inventing devices to demonstrate how moving water can accomplish work in the activity, "Energetic Water."

The publications helpful in conducting this unit are:

1. *Be Water Wise*
2. *Water Cycle Poster*
3. *National Geographic Edition "Water"*
4. "Water in the World" (Enclosed Handout)
5. *Sandcastle Moats and Petunia Bed Holes*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"Water Meter" Construct a water meter and keep track of personal water use	Water is a natural resource.	up to 1 week	217	1, 2
"Choices and Preferences" Develop a water index to rank water use	Water resources exist within social constructs	50 minutes	367	1
"Every Drop Counts" Identify and implement water conservation habits	Water resources are managed.	1 week	307	1,3
"Common Water" Demonstrate that water is a shared resource	Water is a natural resource.	30 minutes	238	4
"Energetic Water" Design devices to make water do work	Water is a natural resource.	variable	242	1
"Water Works" Create a web of water users	Water is a natural resource.	50 minutes	274	1, 2, 5

WATERSHEDS

Geologists define a watershed as the area drained by a river and its tributaries, which are part of smaller watersheds. For example, the North Fork is a tributary of the Shenadoah River, which is a tributary of the Potomac which makes up the larger Potomac River Basin. There are nine major river basins in Virginia (see enclosed "Virginia's Waters Fact Sheet"). All of the activities in this unit for students in grades 3-12 require 100 minutes (at least two class periods) or more to complete.

Available resources to enhance this unit are:

1. *River Basins Fact Sheets*
2. *Bay BC's*
3. *Aquatic Resources and Nonpoint Source Pollution*
4. *Facts about Virginia's Waters*
5. *Water Cycle* Poster

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"Rainy-Day Hike" Explore schoolyard topography and its effect on the watershed	Water connects all Earth systems.	100 minutes	186	2
"Branching Out" Construct a watershed model	Water connects all Earth systems.	100 minutes	129	1, 4
"Capture, Store, and Release" Use a household sponge to demonstrate how wetlands get wet	Water connects all Earth systems.	100 minutes	133	2, 3, 5
"Color Me a Watershed" Interpret maps to analyze changes in a watershed	Water is a natural resource.	130 minutes	223	2, 3, 4

WETLANDS

Wetlands are found in coastal and inland areas, along rivers, lakes, ponds, inlets, and bays. Along the east coast of Virginia there are saltwater wetlands, such as tidal salt marshes or mudflats. Virginia also has freshwater wetlands, including nontidal marshes, wooded swamps, wet meadows, bottomland hardwood forests, bogs, and some shallow areas of ponds. There are over 213,000 acres of wetland marshes fringing the Chesapeake Bay and its tributaries in Virginia. Forming a natural boundary between land and water, these areas serve many vital functions, including the following:

- remove sediment
- absorb the erosive energy of waves
- act as nutrient buffers
- provide food and shelter for numerous animals
- serve as location for abundant growth of plant matter

For a wetlands unit, the following resources will provide information for field study investigations, a field trip, and role-playing activity on how organisms adapt to life in a salt marsh:

1. *Bay BC's*
2. *Water Cycle Poster*
3. *Aquatic Resources & Nonpoint Source Pollution*

Activity Name	Conceptual Framework	Activity Duration	Page	Virginia Resource
"Salt Marsh Players" Role-play organisms adapted to life in a salt marsh	Water is essential for all life to exist.	50 minutes	99	1, 2, 3
"Life in the Fast Lane" Explore temporary wetlands	Water is essential for all life to exist.	up to 1 month	79	1, 2, 3
"Wetland Soils in Living Color" Classify soil types using a simple color key	Water connects all Earth systems.	up to 2 hours	212	1, 2, 3

Virginia's Waters Fact Sheet

- 976 square miles of surface water--lakes, tidal rivers and bays
- 3,000 miles of nontidal rivers and streams
- 374.8 miles of state waters have Virginia Scenic River designations
- 5,000 miles of shoreline
- 450 public fishing streams
- 1,500 miles of stocked trout streams
- 50,00 farm ponds
- 2 natural lakes: Mountain Lake and Lake Drummond
- 160,000 acres of reservoirs
- Nine river basins:
    - Potomac-Shenandoah
    - Rappahannock
    - York
    - James
    - Roanoke
    - New
    - Tennessee-Big Sandy
    - Chowan
    - Coastal Rivers
- Two rivers flow north: New and Shenandoah
- New and Tennessee-Big Sandy flow to the Mississippi River. The other seven flow into the Atlantic Ocean.
- 1,790 caverns in Virginia, nine are open to the public
- 1,600 springs (100 are thermal)
- 157 springs provide water to public waterworks
- Average precipitation is 42 inches a year--12 inches above the national average
- Chesapeake Bay is the largest of more than 800 estuaries in the U.S.
- Draining over 64,000 square miles, the bay holds 18 trillion gallons of water from 50 major rivers
- Two of the five major U.S. East Coast ports are on the Bay--Hampton Roads and Baltimore
- 400 million gallons of groundwater are withdrawn daily
- About 80 percent of Virginians use groundwater for all or part of their everyday water needs

Virginia's Physiographic Provinces

The similar geologic structure of each province affects the quantity, quality, and the natural flow rates of groundwater. The thickness of the soils and the permeability of soils and rocks in the province affects the pollution potential of the groundwater. The average rate of groundwater movement in an aquifer of coarse sand is about 360 feet per year. In a clay confining aquifer the average flow is less than half an inch per year. Only in limestone caverns and karst areas does groundwater movement resemble those of streams and rivers. A well yield of at least 6 gallons a minute is usually needed for home use, though 10 gallons a minute is more desirable.

Cumberland Plateau

Portions of seven southwestern Virginia counties are in the Cumberland Plateau province. This hilly, sparsely populated area is made up of sedimentary rocks (sandstone, shale, and coal) that yield small quantities of groundwater. The quality of the groundwater is poor because of high iron or manganese content or acidity. The potential for groundwater pollution is moderate.

Valley and Ridge

Long, parallel mountain ridges separated by valleys are characteristic of the Valley and Ridge province, which extents for 300 miles from Winchester to Bristol. Limestone, dolomite, shale, and sandstone are the common rock types. The groundwater tends to be hard, calcium-rich water in limestone areas, sulfurous and iron-bearing in shale areas, and of good quality in sandstone areas. Groundwater yields in limestone areas are up to 3,000 gallons a minute while in the ridges and upland areas underlain by sandstone and shale, yields are only enough for domestic use. The potential for groundwater pollution is very high because contaminated surface water often flows directly into the ground through limestone sinkholes.

Blue Ridge

A narrow ridge of mountains with Virginia's highest peaks is the topography of this province. Crystalline rocks, such as granite, gneiss, and marble underlie the steep terrain and thin soil that result in rapid runoff and low groundwater recharge. Domestic wells yield less than 20 gallons a

minute, but the water quality is generally good with iron content high is some areas. Groundwater pollution potential is low.

Piedmont

Bordered on the west by the Blue Ridge Mountains and on the east by the fall line (an imaginary line passing through Emporia, Petersburg, Richmond, Fredericksburg, and Fairfax and crossing Virginia's rivers where they descend from the uplands to the coastal lowland), the Piedmont province is diverse with wide variations in groundwater quality and quantity. Some areas are underlain by granite, gneiss, schist, slate, and marble and a few scattered areas of sandstone and shale. Well yields range from 3 to 20 gallons a minute--an adequate supply of potable water for homes and farms. The groundwater is generally of good quality and the pollution potential in this province is moderate to low.

Coastal Plain

With the Atlantic Ocean and Chesapeake Bay on the east and the fall line on the west, the Coastal Plain stores more water than any other province. It is the only Virginia province composed primarily of sand, gravel, clay, shell rock, and other unconsolidated deposits. The shallow water-table aquifer provides water for domestic wells with yields of 10 to 50 gallons a minute. The deeper artesian aquifers are the source of water for the municipal and industrial wells with yields of 2,000 to 3,000 gallons a minute. The quality of the water is generally good, except in areas where salt water, iron, and hydrogen sulfide occur. There is a high pollution potential because of the highly permeable soils and the shallow aquifers.

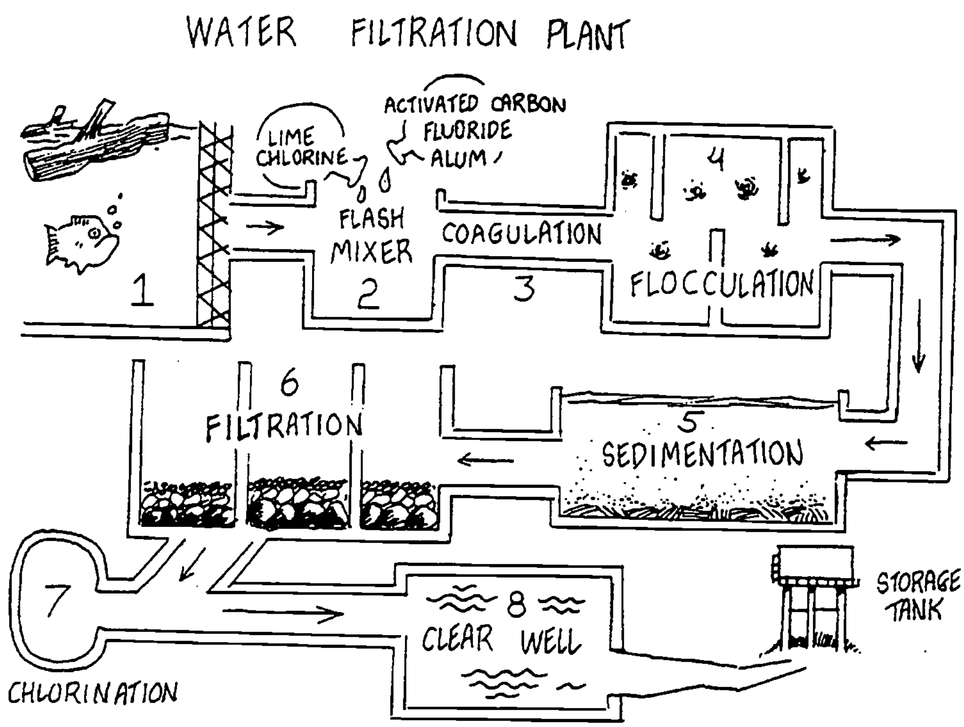
Making Water Usable

For many uses, such as drinking, citizens need water that is cleaner than that found in rivers and lakes. To clean or purify the water, cities and town have built treatment systems, which cost money and require energy to run.

Water is pumped from a lake, river, or reservoir into the water filtration plant.

1. First, it is strained to keep fish and large objects out of the system.

2. Chemicals such as alum, chlorine (to kill bacteria), fluoride (to strengthen teeth), and lime (to prevent rust in water pipes) are added to the water tat the flash mixer. Activated charcoal may also be added if taste and odor are problems.



3. The alum causes a chemical reaction in water than enables the dirt and other particles to stick together. This reaction is called coagulation.

4. Sticky, fluffy particles called floc are created by the alum and during flocculation, dirt and other particles in the water are attracted to the floc and "clump" together.

5. In the sedimentation basins, the floc sinks to the bottom. This sediment, or solid matter, is called sludge and has to be removed from the plant. This disposal of sludge is a big problem for communities.

6. The clear water above the sediment is filtered through layers of sand and gravel to remove remaining dirt and other impurities (filtration).

7. Chlorine is added to kill any bacteria still remaining in the water (chlorination). Some plants may add fluoride and other chemicals at this stage.

8. The filtered, chlorinated water is stored in clear wells and in storage tanks until it is needed.

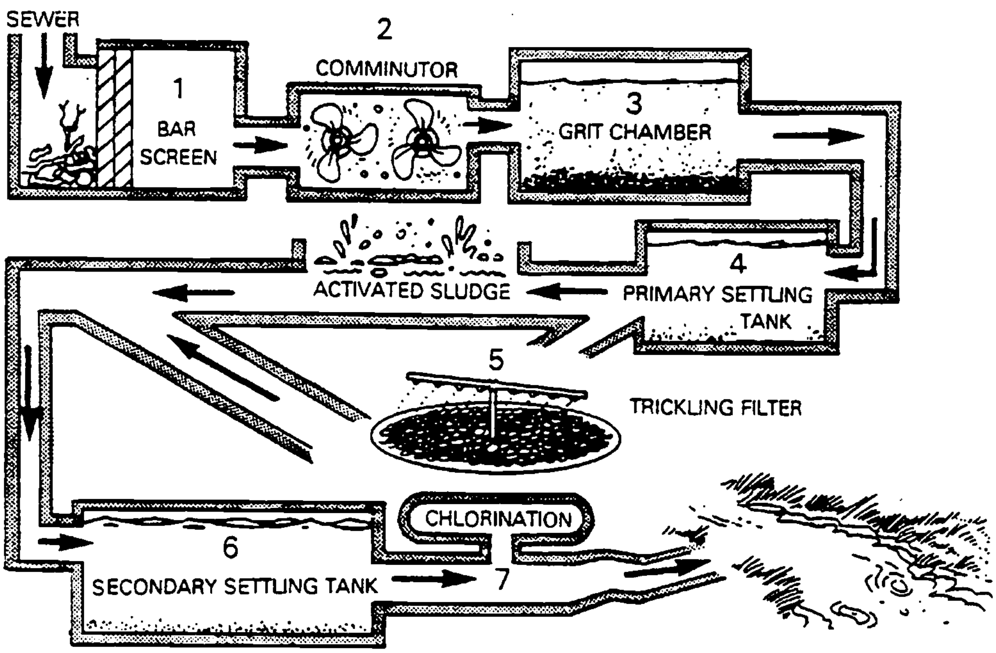
One way to remember the treatment process is to learn the "tion" words: coagulation, flocculation, sedimentation, filtration, and chlorination.

After the water has been treated, it's safe for our use. (Water can become polluted in the pipes or storage tanks before it reaches our homes but this doesn't happen too often.) After we've finished using the water in our homes, it flows down drains and toilets as wastewater.

Treating Wastewater

Most towns and cities with sewage treatment plants are generally required by law to have two phases of sewage treatment: primary and secondary. The first phase removes suspended particles and some oxygen-demanding wastes (plant and animal materials). The second phase removes more of the harmful substances found in wastewater. Here's how a sewage treatment plant might work:

WASTEWATER TREATMENT PLANT



1. The sewage, or wastewater, first flows through a <u>bar screen</u> which removes large objects which could damage equipment.

2. The <u>comminutor</u>, like a garbage disposal, then grinds the materials floating in the sewage into smaller pieces.

3. In the <u>grit chamber</u>, particles like sand and grit settle out and become <u>sludge</u> which is removed.

4. In the primary settling tank, slow-settling solids sink to the bottom and are also removed. These solids usually go to a sludge digester, where bacteria and other microorganisms reduce the size of the sludge. This is the primary phase of treatment which can remove up to 35% of the BOD (biochemical oxygen demand).

5. Next the sewage goes through one of two secondary treatment processes: trickling filter or activated sludge which removes up to 90% of the BOD. With the trickling filter method, the wastewater is sprayed over the bed of the filter by arms that rotate like a sprinkler. The wastewater then trickles down through the bed of rock and gravel which is coated with a layer of bacteria, molds, worms, larvae and other organisms. These organisms simply digest the solid particles remaining in the sewage.

   Some sewage treatment plants use the activated sludge method. Sewage is bubbled by aeration to keep the oxygen level high. This allows microorganisms in the bubbling water to reproduce rapidly and constantly decompose the wastes in the sewage.

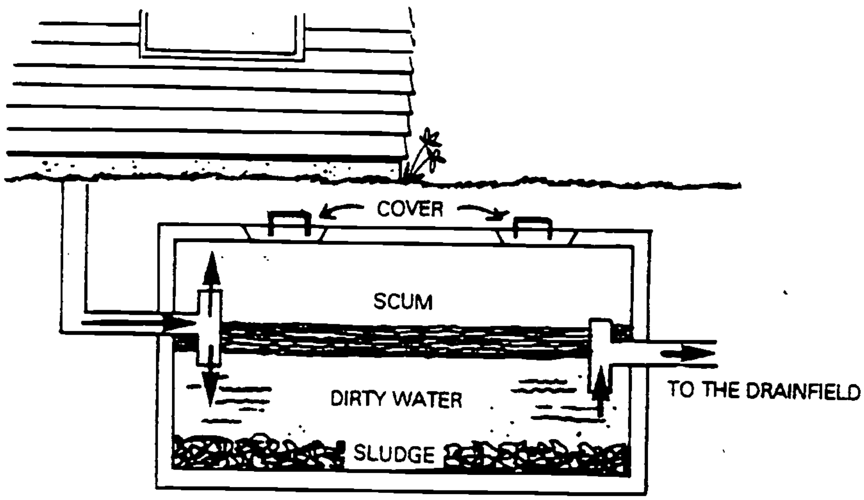
6. Any solid material left in the wastewater then settles out in the secondary settling tank. These solids are also sent to the sludge digester. Disposal of sludge remaining in the digester after bacteria has reduced the size of the solid is a problem. Laws are now being written to help communities deal with sludge disposal.

7. Before the water flows back to the river it is chlorinated to remove any harmful organisms that might remain.

Most, but not all pollutants, are removed from the water. Those that remain may not be directly harmful to humans, but can sometimes create problems in rivers and streams. Nitrogen and phosphorus, for example, are two substances found in wastewater that are not entirely removed with secondary treatment. These substances act as fertilizer and can cause too much algae to grow in the water. When the algae dies, or decays, they reduce the amount of oxygen in the water and the water may taste and smell bad. Since fish and other organisms need oxygen, this condition can cause suffocation and death. Most nitrogen, phosphorus, heavy metals and non-biodegradable organic compounds can only be removed by a third expensive phase, called tertiary treatment.

Septic Tanks

Over one quarter of the homes in the United States are not connected to town or city sewage treatment plants. These 20 million households have their own disposal systems, called septic tanks, which discharge about 800 billion gallons of wastewater into the soil around them each year.



The septic tank system consists of a buried tank in which all wastewater from the house is collected. Inside the tank, scum (including fat and grease) flows through a pipe system to a drainfield in the soil. Aerobic bacteria (bacteria that uses oxygen) in the soil digest the solids in the liquid waste while the soil acts as a natural filter. Some anaerobic bacteria (bacteria that do not use oxygen) digest some of the solid sludge, which reduces the amounts of solids in the tank. The sludge and scum, called septage, are pumped out of the tank every few years. This septage, if it is not cleaned and disposed of properly, can create health problems and injure the environment. If a septic tank isn't taken care of correctly or if the soil around it isn't suitable for absorbing the liquid waste, a septic system may not work correctly and could pollute ground and surface water.

Desalination

Ninety-six percent of the earth's water is in its oceans. As we use more and more of the remaining 4 percent of fresh water, the need increases to turn to the great supply of ocean water. Before this water can be used, however, the salt must be removed. The process of removing salt from water is called desalination.

Several methods exist to accomplish desalination. Distillation, freezing, and reverse osmosis remove the water from the salt. Ion transport, (also called membrane technology) and chemical methods remove the salt from the water.

Distillation as a desalination process dates back possibly to the ancient Greeks. Eighth century Arab scientists perfected its use. This still-like method involves boiling the saltwater, capturing the pure steam, and condensing it into fresh water. Sailing ships from the time of Drake have supplemented their water supplies through this process, and it is still an important desalination process.

Another method of desalination involves freezing the saltwater. Incompletely frozen saltwater separates into nearly saltless ice crystals and a concentrated brine.

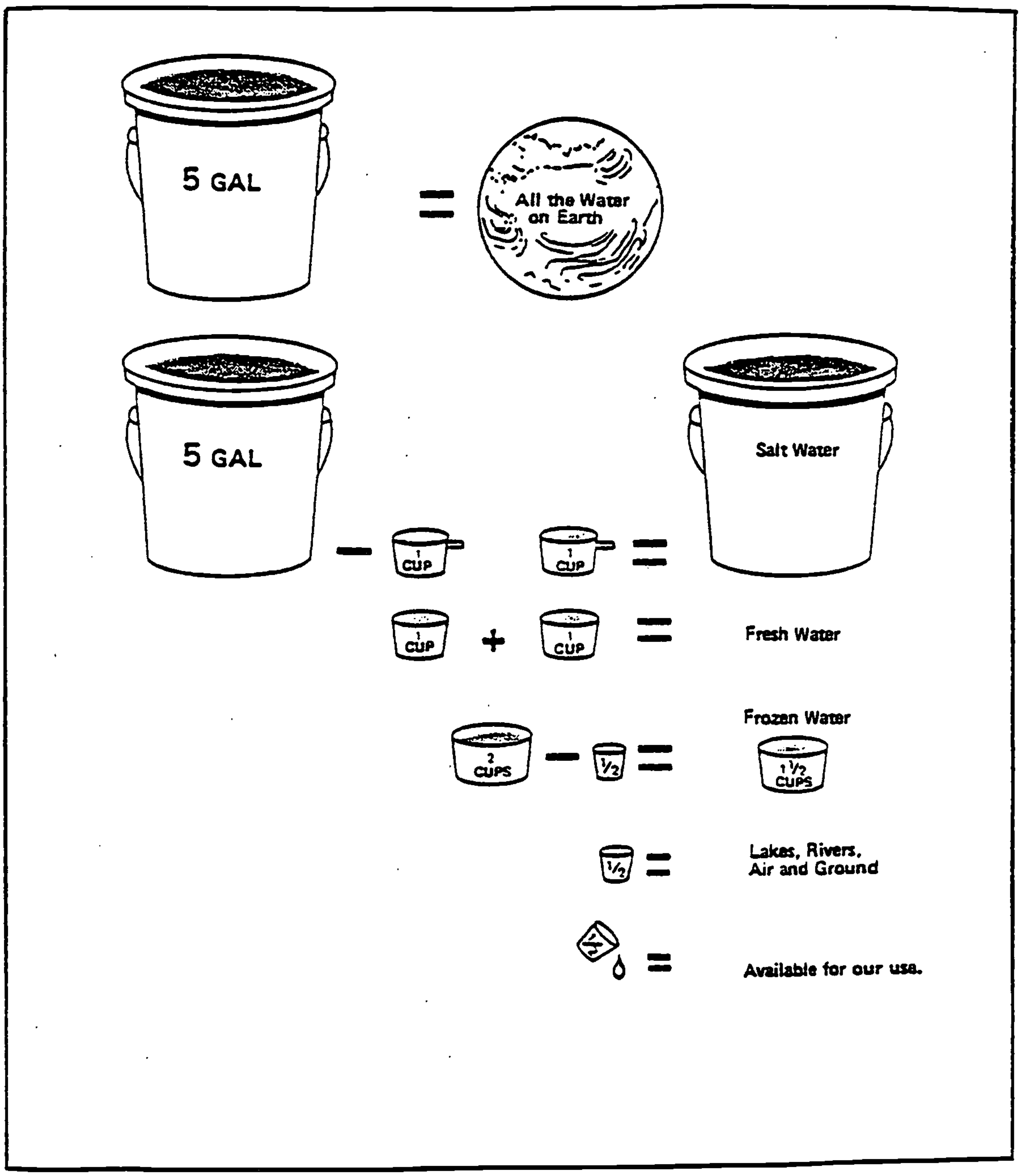
The third method that removes the water from the salt is reverse osmosis. Using a nonporous membrane of special structure, sufficient pressure is applied to me saltwater in contact with the membrane to force the water through. The salt is left behind.

The most modern method of desalination is ion transport, or membrane technology. A current of electricity splits the salt molecules into ions (electrically charged particles). These ions diffuse through special membranes, and fresh water is left.

Chemical methods include open exchange and precipitation and are used most frequently to soften water.

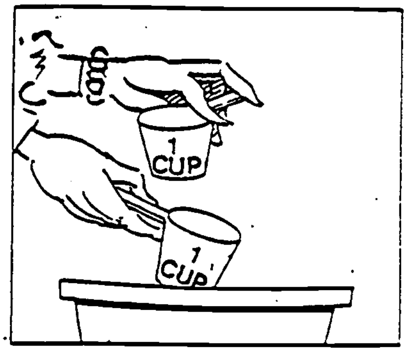
Regardless of the knowledge of how to accomplish desalination, it has not been used to any great extent because it requires a great deal of energy. And, energy costs money. However, as the need for fresh water increases and better technology is developed, the world's oceans may provide much of future water supplies.

WATER IN THE WORLD

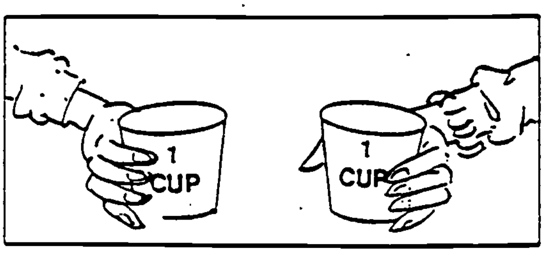


WATER IN THE WORLD

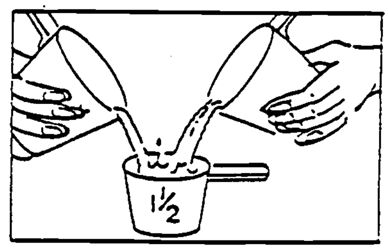
This represents all the water on earth.



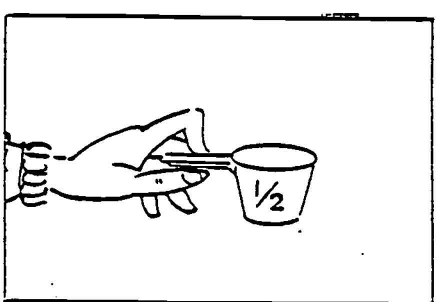
Remove 2 cups. All that remains in the bucket represents the salt water on the earth.



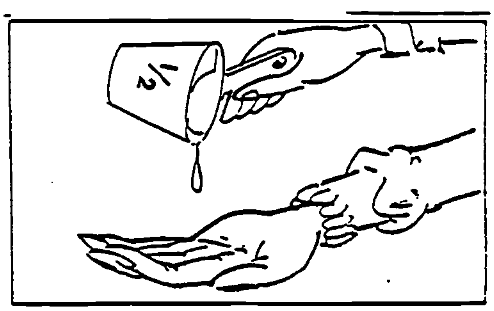
These 2 cups represent all the freshwater.



Remove a 1/2 cup. What remains is the frozen water on the earth.



This 1/2 cup represents the water in the lakes, rivers, air and ground.



This one drop is all that is available for our use.

Contaminants in Water: How Much Is Too Much?

IN 1987, Monsanto was ordered to pay $16.2 million in punitive damages for a chemical spill in Sturgeon, Missouri. At issue were 19,000 gallons of a raw material used in a wood preservative that included, according to newspaper accounts, "less than a teaspoon" of the carcinogen dioxin. A teaspoon seems like a negligible amount, especially diluted by 19,000 gallons. How do you decide if it will be harmful?

Tests for carcinogenicity, or the ability of a substance to cause cancer, have allowed scientists to predict that a lifetime exposure to 2.2×10^{-7} microgram per liter ($\mu g/l$) of dioxin will result in one "extra" cancer death for every million people.[1] A gram in a liter is roughly equivalent to two thousandths of a pound in a quart. A microgram is a *millionth* of a gram. And the number 2.2×10^{-7} microgram is equal to 0.00000022 — less than a *millionth* — of a microgram. That's not much dioxin. If everyone in Virginia were exposed to that concentration, however, six of Virginia's nearly six million residents would die from dioxin-induced cancer. Exposure to higher concentrations of dioxin would result in even more cancer deaths.

A concentration of 2.2×10^{-7} $\mu g/l$ is not easy to imagine. An example using ordinary table salt, a familiar substance, may help to illustrate. Suppose that salt, instead of being a flavor enhancer for food, were a carcinogen as powerful as dioxin. One teaspoon of table salt weighs about 7 grams, or a quarter of an ounce. If you mixed a teaspoon of salt into 840,600 gallons of water — more than 23,000 bathtubs full — it would be far too dilute to taste salty. In fact, you'd have no reason to suspect you weren't drinking "pure" water. But a teaspoon of salt in 840,600 gallons would be a *million times* more concentrated than 2.2×10^{-7} $\mu g/l$, dioxin's cancer risk level. In other words, you'd have to put your spoonful of salt into 840,600,000,000 gallons —more than 840 *trillion* gallons — just to dilute it to the same concentration as dioxin's cancer risk level.

How is it possible that such a little bit of something dissolved in so much water can endanger human health? Salt — like all substances — is composed of very small individual particles, or atoms. The number of individual atoms in a teaspoon of salt is enormous. When that teaspoonful is added to water, the atoms spread until they're evenly distributed throughout all the available water, no matter how large the volume. If you took a quarter of a cup — just a gulp—of water containing our imaginary carcinogenic salt at the very low concentration set as the cancer risk level for dioxin, you'd drink more than 100 million atoms of salt!

What usually happens in an aquifer is more complicated. Near the spill, the concentration of contaminant is quite high, but the concentration decreases as the contaminant moves away from the spill site into cleaner water. Contaminant movement is affected by solubility, the type of rock or soil making up the aquifer, the number and location of wells tapping the aquifer, and other factors. When and where contaminants will appear in an aquifer or a well is difficult to predict because so many factors influence their direction and rate of movement in groundwater.

At first glance, a penalty of $16.2 million to a company that spilled a teaspoon of a substance diluted by 19,000 gallons may seem unreasonably harsh. We hope these calculations help to show that "a little can go a long way" — and with highly carcinogenic or toxic substances, a little going a long way can be a real threat to human health.

[1] The cancer risk level for dioxin was being reassessed by the Environmental Protection Agency in 1988.

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